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FORMULATION AND EVALUATION OF METFORMIN HYDROCHLORIDE LIQUISOLID TABLETS

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ABSTRACT

The present research aimed at formulating and evaluating of Metformin hydrochloride Liquisolid tablets using different non - volatile solvents, carrier materials and coating materials. The excipients were selected on the basis of compatibility studies by FTIR studies. Metformin was taken as formulating drug into Liquisolid tablets. Preformulation studies such as bulk density, tapped density, % compressibility index, angle of repose was performed. Four formulation trials were done for optimization and F4 was found to be optimized formulation. Evaluation tests were conducted for the optimized formulation F4. Weight variation was within limit, thickness of 5.23 ± 0.05, hardness of 5.32 ± 0.9 and % friability of 0.73 ± 0.3 were found. *In Vitro* dissolution study was conducted for 120 min (2 hrs) and the cumulative % drug release was found to be 95.54 ± 0.7 %. Stability studies were carried out for 3 months as per ICH guidelines. The formulation was stable during this period.

KEYWORDS: Compatibility, Liquisolid tablets, Preformulation studies, Optimized formulation.

INTRODUCTION

Liquisolid technology also called as “Powder Solution Technology”. It is the most promising & novel techniques to improve the dissolution rates of the poorly water-soluble drugs. The concept of powder solution technology is to convert the liquid drug into free flowing readily compressible powder. Here the liquid drug (or) liquid medication is the water insoluble drug

dissolved in a non-volatile solvent.

These liquid drugs are converted to free flowable & compressible powder by the addition of suitable excipients like carriers, coating materials, lubricants, disintegrants & glidants etc. The compression can be proceeded by direct compression.

The Liquisolid technology as described by Spireas is a liquid which is transformed into a free flowing, readily compressible and apparently dry powder by simple physical blending with selected excipients like the carrier and coating material.[1,2,3]

COMPONENTS[4,5,6]

Drug: The drug used in Liquisolid systems must be water insoluble, low dose drugs. It must be in BCS class II and IV. E.g.: Digoxin, Digitoxin, Prednisolone, Hydrocortisone, Water insoluble vitamins, Fish oil etc.

Non-volatile solvent: It must be inert water miscible, not highly viscous and should have high boiling point. E.g.: PEG 200 and 400, Glycerine, N, N dimethyl acetamide, Span 80 &19, Tween 80&19 Propylene glycol and etc.

Carrier materials: These are highly porous materials & have a wide surface area and the recommended to absorb the drugs on to them. E.g.: Cellulose (microcrystalline & amorphous), starch, sorbitol, Lactose, MCC (Avicel PH102), DCP, Eudragit RS&RL.

Coating materials: There are fine materials having a particle size range from 10 nm to 4560 mm in diameter. These must be highly adsorptive to cover the carrier particles and show dry look. E.g.: Silica of various grades like cab-o-sil M5, Aerosil 200 and Syloid 244fp etc.

Disintegrants: These are used to break the compacts to smaller particles. Eg: Croscarmellose sodium, Cross povidone, Explotab and Pre gelatinized starch etc.

Lubricants: These are intended to reduce the friction. E.g.: Stearic acid, Stearic acid salts and Talc etc.

Glidants: Intended to promote the flow between particles by reducing the friction.: Silica derivatives, Talc and Corn starch etc.

Liquid medication includes liquid lipophilic drugs and drug suspensions or solutions of solid water insoluble drugs in suitable non-volatile solvent systems.

Liquisolid systems refer to powdered forms of liquid medications formulated by converting liquid lipophilic drugs, or drug suspensions or solutions of water insoluble solid drugs in

suitable non-volatile solvent systems, into dry, non-adherent, free-flowing and readily compressible powder admixtures by blending with selected carrier and coating materials.

Carrier material refers to a preferably porous material possessing sufficient absorption properties, such as microcrystalline and amorphous cellulose, which contributes in liquid absorption.

Coating material refers to a material possessing fine and highly adsorptive particles, such as various types of silica, which contributes in covering the wet carrier particles and displaying a dry looking powder by adsorbing any excess liquid.

Flowable Liquid retention potential [Φ]: It defined as the maximum amount of liquid that the unit weight of a powder material can retain inside its bulk while at the same time maintaining acceptable flowability. [Or]

The ability of a powder material to retain a specific amount of liquid while maintaining good flow properties. The flowability may be determined from the powder flow or by measurement of the angle of repose.[7,8]

Compressible liquid retention potential [Ψ][9,10]

The Ψ-number of a powder is defined as the maximum amount of liquid the powder can retain inside its bulk [w/w] while maintaining acceptable compactability resulting in compacts of sufficient hardness with no liquid leaking out during compression.

A powder can retain only limited amounts of liquid while maintaining acceptable flow and compression properties. To calculate the required amounts of powder excipients (carrier and coating materials) a mathematical approach for the formulation of Liquisolid systems has been developed by Spireas. This approach is based on the flowable (Φ-value) and compressible (Ψ-number) liquid retention potential.

Excipient Ratio (R): In some cases, however, the dosage formulation may require a specific ratio of carrier/coating material in the final powder admixture. This ratio termed as the excipient ratio,''R''.

Liquid load factor (Lf): Lf represents the ratio between the mass of the liquid portion W and the carrier's materials Q:

$$Lf = W / Q$$

With the desired amount of liquid, the amount of carrier and coating material can be calculated if the liquid load factor Lf is known.

Mechanisms of enhanced drug release from Liquisolid systems

1. Increased drug surface area
2. Increased aqueous solubility of the drug
3. Improved wetting properties

MATERIALS AND METHODS

Table No. 1: Materials used for the study.

S. No.	Material Name	Manufacturer
1	Metformin Hydrochloride	Yarrow Chem, Mumbai
2	Polyethylene Glycol - 400	Loba Chem, Mumbai
3	Microcrystalline Cellulose PH -102	Loba Chem, Mumbai
4	Aerosil	Loba Chem, Mumbai
5	Lactose	Loba Chem, Mumbai

Table No. 2: Equipment used for the study.

S. No.	Name of the equipment	Manufacturer
1	U.V-Vis Spectrophotometer	LABINDIA - UV3092
2	Dissolution Apparatus	LABIDIA- DS 8000
3	Punching machine	RIMEK, KARNAVATHI
4	Friabilator	CAMPBELL
5	Weighing balance	SHIMADZU, JAPAN
6	Disintegration tester	ROLEX
7	Hardness tester	MONSANTO
8	Hot air oven	FORTUNE

DRUG PROFILE

METFORMINE HYDROCHLORIDE[11]

Empirical formula: $C_4H_{11}N_5HCl$.

Molecular weight: 165.625 g/mol.

Description

Metformin hydrochloride is a white crystalline powder which is odourless or almost odourless and hygroscopic It is freely soluble in water, slightly soluble in ethanol and practically insoluble in chloroform and in ether.

Melting point: 223-226 ^{0} C

PREFORMULATION STUDIES

Drug and excipient compatibility studies

Bulk density

Tapped density

%Compressibility index

Hausner's ratio

Angle of repose

DRUG AND EXCIPIENT COMPATIBILITY STUDIES

FOURIER TRANSFORMS INFRARED SPECTROSCOPIC ANALYSIS[12,13,14]

Compatibility of the drug with recipients was determined by FT-IR spectral analysis, this study was carried out to detect any changes on chemical constitution of the drug after combined it with the excipients. The samples were taken for FT-IR study.

After ultrasonication, the polymeric suspension was sprayed on to an aluminium slip with the aid of an atomizer. The fine droplets were dried overnight at room temperature and the solid samples were then collected and powdered. This powder sample was used for FTIR analysis. The Fourier transform infrared analysis was conducted to verify the possibility of interaction of chemical bonds between drug and polymer. FTIR analysis was performed by FTIR Spectrophotometer interfaced with infrared (IR) microscope operated in reflectance mode 29. The microscope was equipped with a video camera, a liquid Nitrogen-cooled Mercury Cadmium Telluride (MCT) detector and a computer-controlled translation stage, programmable in the x and y directions. Solid powder samples were oven dried at about 30°C, finely crushed, mixed with potassium bromide (1:100 ratio by weight) and pressed at 15000 psig (using a Carver Laboratory Press, Model C, Fred S. carver Inc., WIS 53051) to form disc. The spectra were collected in the 400 cm-1 to 4000 cm-1 regions with 8 cm-1resolution 60 scans and beam spot size of 10 µm -100µm. The FTIR imaging in the present investigation was carried out using a Perkin Elmer spectrum RX.

A) BULK DENSITY[15]

Bulk density is defined as the mass of powder divided by bulk volume; it is calculated using the following equation:

Bulk density = weight of sample / volume

An accurately weighed quantity of the powder (W) was carefully poured into the graduated

cylinder and the volume (V o) was measured. Then the cylinder was dropped at 2-second intervals onto a hard wooden surface three times, from a height of one inch. The volume was recorded and the bulk density was calculated.

B) TAPPED DENSITY[15]

An accurately weighed quantity of the powder (W) was carefully poured into the graduated cylinder and the volume (v_o) was measured. Then the surface was carefully smoothed and the volume was measured. Tap density was calculated by measuring final volume (V_f) after 50 taps on wooden surface from 6-inch height and was expressed in g/cm^3.

Bulk density = W/V_o

Tapped density = W/V_f

Where,

V o = initial volume.

V f = final volume.

C) COMPRESSIBILITY INDEX & HAUSNER RATIO[15]

The Compressibility index and Hausner's ratio are measures of the propensity of a powder to be compressed. As such, they are measures of the relative importance of underarticulate interactions in a free-flowing powder, such interactions are generally less significant, and the bulk and tapped densities will be closer in value. For poorer flowing materials, there are frequently greater interparticle interactions and a greater difference between the bulk and tapped densities will be observed. These differences are reflected in the Compressibility Index and the Hausner's Ratio. The compressibility index and Hausner's ratio may be calculated using measured values for bulk density (bulk) and tapped density (tapped).

D) ANGLE OF REPOSE[15]

The flow characteristics are measured by angle of repose. Improper flow of powder is due to frictional forces between the particles. These frictional forces are quantified by angle of repose.

Angle of repose is defined as the maximum angle possible between the surface of a pile of the powder and the horizontal plane.

$$\text{Tan } \theta = h/r$$

$\theta = \tan^{-1} (h/r)$

Where,

ɵ is the angle of repose,

h is the height,

r is the radius.

Table No. 3: Formulation composition of Metformin hydrochloride Liquisolid tablets.

S.No.	Ingredients	F1(mg)	F2 (mg)	F3(mg)	F4(mg)
1	Metformin HCl	50	50	50	50
2	PEG 400	50	50	50	50
3	Microcrystalline Cellulose	180	200	200	225
4	Aerosil	15	5	10	24
5	Sodium Starch glycolate	15	5	5	20
6	Lactose	90	90	75	41

PROCEDURE[16,17,18]

Drug: Metformin hydrochloride

Liquid vehicle: PEG 400

Carrier material: Microcrystalline cellulose

Coating material: Aerosil

Preparation and mixing of the powders: The amounts of excipients depended on their Φ - values, as well as liquid load factors. Aerosil was used as coating material, while Avicel PH 102 was used as carrier. The liquid load factor Lf = 0.222.

By using following formula, the required amount of carrier and coating materials are calculated.

Lf = W/Q

Lf = Liquid load factor

W = Weight of liquid

Q = Weight of carrier

Metformin hydrochloride was suspended in polyethylene glycol 400 (PEG 400), and the suspension was made into slurry by mixing it with Avicel PH 102 (carrier).

The excess fluids were adsorbed by Aerosil 200 (coating material), that was added later. Sodium starch glycolate was finally added to the powders to make 5 % of the tablet weight.

Compression of the Powders: Liquisolid tablets were prepared by direct compression method using eight station rotary punch tablet compression machine.

EVALUATION TESTS[19,20]

A) WEIGHT VARIATION

Twenty tablets were randomly selected from each batch and individually weighed. The average weight and standard deviation of 20 tablets was calculated. The batch passes the test for weight variation test if not more than two of the individual tablet weight deviates from the average weight by more than the percentage and none deviate by more than twice the percentage shown.

Table No. 4: USP limits for weight variation.

Average wt. of tablet (mg)	Percentage deviation (%) ±
<130	10
123 - 324	7.5
>324	5

B) THICKNESS

Three tablets were randomly selected from each batch and their thickness was measured by using vernier callipers. Thickness of three tablets from each batch was measured and mean was calculated.

C) HARDNESS

Hardness indicates the ability of a tablet to withstand mechanical shocks while handling. The hardness of the tablets was determined using Monsanto hardness tester. It is expressed in kg/cm^2. Three tablets were randomly picked and hardness of the tablets was determined.

D) FRIABILITY

Friability test is performed to assess the effect of friction and shocks, which may often cause tablet to chip, cap or break. Roche Friabilator was used for the purpose. This device subjects a number of tablets to the combined effect of abrasion and shock by utilizing a plastic chamber that revolves at 25 rpm dropping the tablets at distance of 6 inches with each revolution. Five tablets were weighed and placed in the Roche Friabilator, which was then operated for 25 rpm for4 min. After revolution Tablets were dedusted and reweighed. Compressed tablets should not lose more than 1% of their weight.

The percentage friability was measured using the formula,

$\% F = \{1-(Wo/W)\} \times 100$

% F = friability in percentage

W_0 = Initial weight of tablet

W = weight of tablets after revolution

E) DRUG CONTENT

The Metformin hydrochloride matrix tablets were tested for their drug content. Twenty tablets were finely powdered; 400 mg of the powder was accurately weighed and transferred to a 50-ml volumetric flask. Then the volume was made up with 0.1 N HCl and shaken for 10 mins to ensure complete solubility of drug. The mixture was centrifuged and 10 ml of the supernatant liquid was diluted 20 times with 0.1 N HCl, and after centrifugation the absorbance was determined Spectro-photometrically (UV – visible 1800, Shimadzu) at 271 nm.

F) *IN- VITRO* DRUG RELEASE STUDY[21,22]

In Vitro dissolution study was carried out using USP II (Paddle) apparatus in 900ml 0.1 N HCl for first two hours. Then the dissolution was carried in 900 mL of P H 6.8 phosphate buffer for 10 hours. The temperature of the dissolution medium was kept at 37± 0.5˚C and the basket was set at 100 rpm. 5 ml of sample solution was withdrawn at specified interval of time and filtered through 0.45 µm Whatman filters. The absorbance of the withdrawn samples was measured at λmax 271 nm using UV visible spectrophotometer. The concentration was determined from the standard curve of Metformin HCl drug prepared in P H 6.8 phosphate buffer at λ max 271 nm.

RELEASE KINETICS OF IN VITRO DISSOLUTION

All the three formulations of prepared matrix tablets of Metformin HCl were subjected to in-vitro release studies these studies were carried out using dissolution apparatus. The dissolution medium consisted of 900 mL PH 6.8 phosphate buffer & 0.1 N HCl.

The results obtaining in vitro release studies were plotted in different model of data Treatment as follows:

1. Cumulative % drug release vs. time (zero order rate kinetics).
2. Log % drug retained vs. time (First Order rate Kinetics).
3. Cumulative % drug release vs. square root of time (Higuchi's plot).
4. Log cumulative % drug release Vs log time (Peppas plot).

STABILITY STUDIES

Stability studies of the optimum formulation were performed at ambient humidity conditions, at room temperature, at 40 o c ± 2 0 C, 75% RH and 2-8 0 c for a period up to 3 Months.

The samples were withdrawn after periods of 1month,2 month and 3 month and were analysed for its appearance, hardness, friability, drug content and in vitro drug release.

RESULTS AND DESCUSSIONS

The excipients are selected based on compatibility studies by F.T. I.R spectroscopy of the drug, excipients. From the F.T. I.R graphs it can be inferred that the functional groups of Metformin HCl have not majorly shifted. From this it can be conformed that the drug and excipients are compatible.

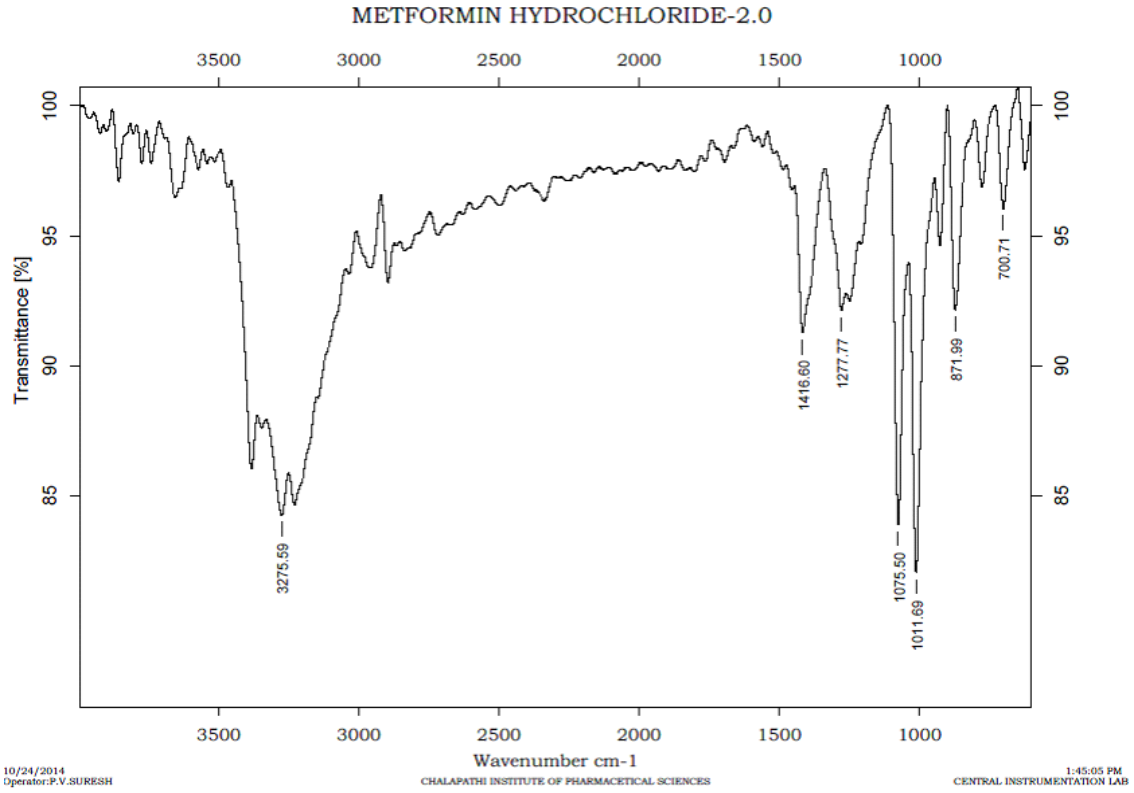

Fig. No. 1: FTIR Spectra of Metformin HCl.

Table No. 4: Preformulation parameters of the formulations.

Parameter	F1 (g/ml) ± SD	F2 (g/ml) ± SD	F3 (g/ml) ± SD	F4 (g/ml) ± SD
Bulk density (g/ml)	0.34 ± 0.05	0.32 ± 0.02	0.35 ± 0.08	0.36 ± 0.02
Tapped density (g/ml)	0.53 ± 0.12	0.54 ± 0.18	0.52 ± 0.06	0.53 ± 0.16
% Compressibility index	17.96 ± 0.05	16.26 ± 0.06	17.25 ± 0.02	18.55 ± 0.05
Angle of repose (^{0})	28.58 ± 0.6	26.42 ± 0.2	27.48 ± 0.4	26.52 ± 0.5

Table No. 5: Various physical properties of metformin hydrochloride Liquisolid tablets.

Formulation Code	F1	F2	F3	F4
Weight Variation(mg) SD	400 ± 0.6	400 ± 0.8	400 ± 0.7	400 ± 0.9
Thickness(mm) ± SD	5.23 ± 0.04	5.23 ± 0.06	5.23 ± 0.04	5.23 ± 0.05
Hardness (Kg/cm^2) ± SD	5.23 ± 0.8	5.53 ± 0.4	5.13 ± 0.13	5.32 ± 0.9
Friability (%)	0.73 ± 1.2	0.73 ± 0.2	0.73 ± 0.1	0.73 ± 0.3

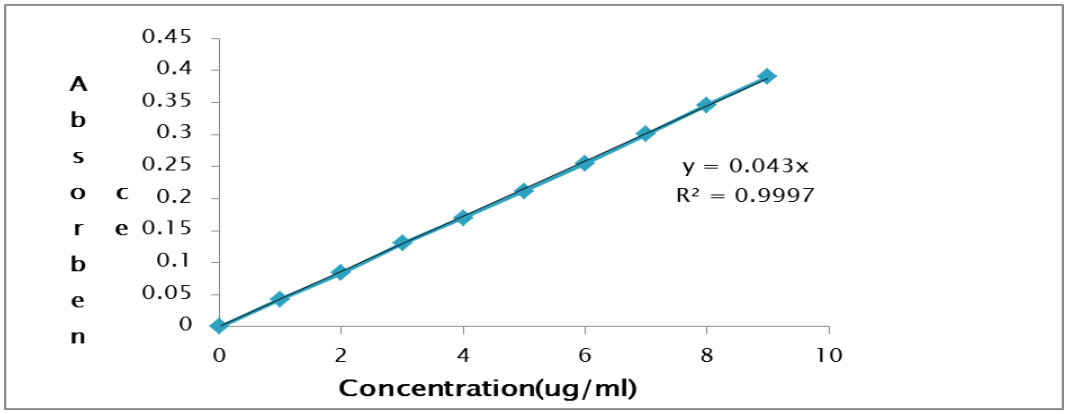

Fig. No. 2: Calibration curve for Metformin HCl.

Table No. 6: Cumulative % of drug release from Formulations F1- F4.

Time (min)	Cumulative % of drug release ± SD			
	F1	F2	F3	F4
15	24.50 ± 0.12	28.05± 0.14	30.92± 0.9	43.26± 0.6
30	26.36± 0.15	33.65± 0.13	41.25± 0.8	61.32± 0.16
45	30.02± 0.7	42.85± 0.15	52.12± 0.6	72.35± 0.5
60	34.54± 0.16	51.20± 0.12	56.35± 0.8	78.29± 0.4
75	39.09± 0.13	57.23± 0.14	60.54± 0.5	80.21± 0.6
90	43.63± 0.15	62.25± 0.13	63.56± 0.7	86.39± 0.3
105	51.02± 0.17	65.53± 0.5	69.25± 0.9	91.28± 0.5
120	61.24± 0.14	68.35± 0.15	75.62± 0.6	95.54± 0.7

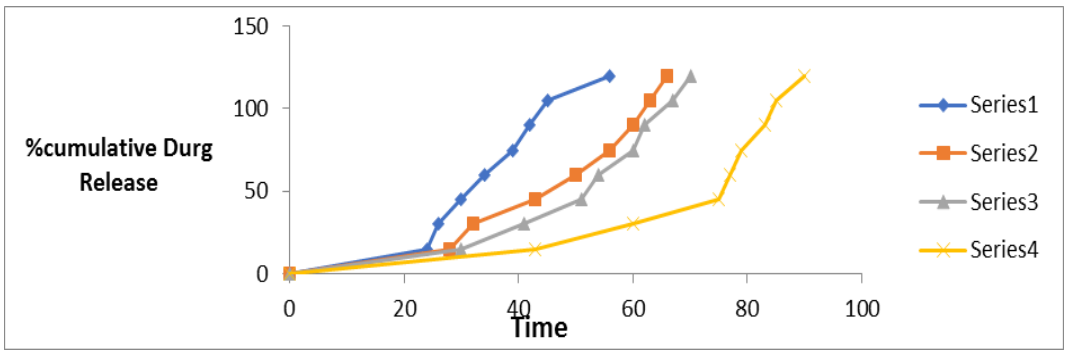

Fig. No. 3: Cumulative % of drug release from Formulations F1- F4.

Table No. 7: Stability study data for F4 Formulation.

Characteristics tested	Specifications	Initial	1st Month	2nd Month	3rd Month
Description	Pale yellow colored round shaped tablets	Complies	Complies	Complies	Complies
Identification By IR Studies	The specific functional group peak of nifedipine not shifted	Complies	Complies	Complies	Complies
Dissolution (%)	Not more than 90% of the drug should be released in 2 hrs.	95.25	96.66	94.22	97.34
Assay (UV-Visible spectroscopy) %	The Nifedipine tablets contain not less than 96.0% and not more than 102.0% of the stated amount of nifedipine	98.6	99.24	98.68	99.88

REFERENCES

1. Jayshri Y. Chaudhari, Bharat W. Tekade, Vinod M. Thakre and Vijay R. Patil. "Formulation and evaluation of nifedipine Liquisolid tablets" International Journal of Pharmaceutical Sciences and Research. IJPSR, 2014; 5(2): 588-595.
2. Shailesh T. Prajapati,1 Hitesh H. Bulchandani,1 Dashrath M. Patel, Suresh K. Dumaniya, and Chimanbhai N. Patel. Formulation and Evaluation of Liquisolid Compacts for Olmesartan Medoxomil. Journal of Drug Delivery, January 2013; 3(2).
3. J. Kapure, V. V. Pande, and P. K. Deshmukh. Dissolution Enhancement of Rosuvastatin Calcium by Liquisolid Compact Technique**.** Journal of Pharmaceutics, Nov. 2013; 3(2).
4. P. Ujwala Reddy, Venkateswara Reddy, Navaneethan. Formulation and evaluation of candesartan immediate release tablets by using Liquisolid technique. World journal of pharmacy and pharmaceutical sciences, July 2011; 3(2).
5. Rajkumar Gudikandula, Kalla Madhavi, Swathi Rao Thakkalapally, Anilkumar Veeramalla and Indarapu Rajendra Prasad. Enhancement of solubility and dissolution rate of ezetimibe through Liquisolid technique. International Journal of Pharmaceutical Sciences and Research.IJPSR, Nov. 2013; 4(8).
6. Boghra, Rikisha; Patel, Anuradha; Desai, Hetal; Jadhav, Anil. Formulation and evaluation of irbesartan Liquisolid tablets. International Journal of Pharmaceutical Sciences, July-2011; 9(2).
7. Keerthi Kamagoni, Prabhu Goud Gunnala and Jaganmohan Somagoni. "Preparation and enhancement of dissolution rate of amlodipine besylate and valsartan using Liquisolid technique. Pharmacie Globale (IJCP), Nov. 2013; 4(06).

8. Soujanya Bodakunta M. Srujan Kumar, Dr.K.V. Subrahmanyam, Shubhrajit Mantry. "Enhancement of solubility of Efavirenz by Liquisolid compact technique. International Journal of Pharmaceutical Sciences, Nov. 2013; 3(1).
9. www.rxlist.com
10. Dnyanesh Walunj, Yogesh Sharma, Swathi Rawat and Kiran Bhise. Formulation development and evaluation of Tamoxifen citrate Liquisolid system. International Journal of Pharma and Bio Sciences, Oct. 2012; 4(3).
11. Kamalanayan, M. Karthikraja, Karthikeyan, K.G.S. Arul Kumaran, R. Pushpalatha." Formulation of tinidazole Liquisolid tablets and invitro evaluation. International Journal of Biological & Pharmaceutical Research, Nov. 2012; 4(3).
12. Alay Prashanth Kumar et al. Solubility enhancement of Simvastatin by Liquisolid compact technique. International Journal of Advanced Pharmaceutics, July 2012; 4(2).
13. Shyam J, Ravi Krishna V, Madhavi K, Vamshi Krishna M and Sudheer Kumar D. "Enhancement of solubility and dissolution properties of Lovastatin by Liquisolid technique. International journal of research in pharmacy and chemistry, July 2014; 3(4).
14. Sandip Vaji." Enhancement Of Dissolution Rate of Poorly Water-Soluble Diclofenac Sodium by Liquisolid Technique". International journal of pharmaceutical and chemical sciences, Sep. 2012; 1(3).
15. B. Anuhya, A. Seetha devi. ". Preparation and in-vitro evaluation of pitavastatin Liquisolid compacts. An International Journal of Advances in Pharmaceutical Sciences, July-August 2014; 5(4).
16. M. A. Hassan and H. M. El-Saghir. Enhancement of dissolution and the anti-inflammatory effect of nimesulide, using Liquisolid compact for oral application. Bull. Pharm. Sci., Assiut University, 34, Part120.
17. Nagaich, U., Pharmaceutical applications of Liquisolid technique. Journal of advanced pharmaceutical technology & research, 2018; 9(2): 43.
18. Patil, J., Liquisolid Compact Technique: A Novel Approach to Solubility Enhancement. Journal of Pharmacovigilance, 2015.
19. Javadzadeh, Y., Effect of some commercial grades of microcrystalline cellulose on flowability, compressibility, and dissolution profile of piroxicam Liquisolid compacts. Drug development and industrial pharmacy, 2009; 35(2): 243-251.
20. Sruti, J., Improvement in dissolution rate of cefuroxime axetil by using poloxamer 188 and Neusilin US2. Indian journal of pharmaceutical sciences, 2013; 75(1): 67.